Atomic Clock with Enhanced Stability (ACES) Proposers Day

Robert Lutwak

Microsystems Technology Office

February 1, 2016

Proposers' Day Agenda

- 9:00 am: Security Overview
- 9:05 ACES Introduction and BAA Overview
  - Program objectives
  - BAA and proposal process
- 9:50 am: GFE Presentations
- 10:35 am: Break and submission of questions
- 11:05 am: Q & A Session
  - Write your questions on the notecards provided
  - Submit questions before the Q & A session begins
- 11:25 am: Attendee Presentations
  - 12 minutes to speak, 3 minutes for questions
  - Please help maintain the schedule
- 12:00 pm: Lunch break (on your own)
- 1:15 pm: More Attendee Presentations
- 4:00 pm: Poster Session

Timeline for Submission

January

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						

February

Su	Mo	Tu	We	Th	Fr	Sa
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29					

March

Su	Mo	Tu	We	Th	Fr	Sa
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

April

Su	Mo	Tu	We	Th	Fr	Sa
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

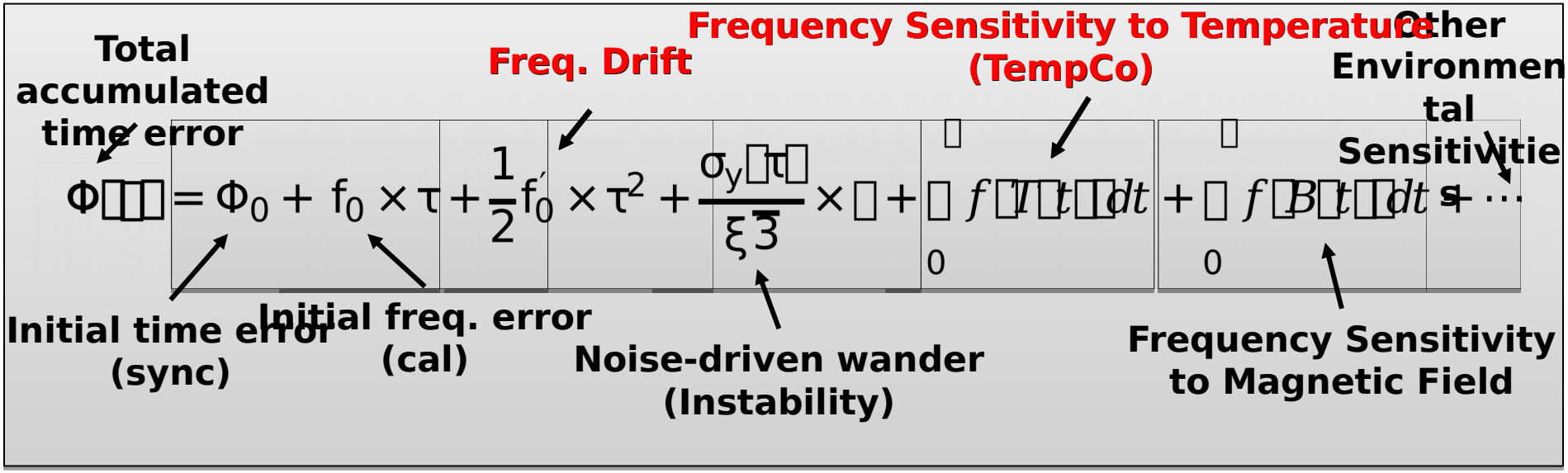
May

Su	Mo	Tu	We	Th	Fr	Sa
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

KEY DATES FOR SUBMISSION

- BAA Announced – **21JAN16**
- Proposers Day – **1FEB16**
- Abstracts Due – **1MAR16**
- Proposals Due – **1 MAY16**

Timing Error



CSAC Typical application model (T=10°C)

Error Source		Timing error, , after 6-hour calibration			
		= 1 hour	1 day	1 week	1 month
Initial Sync	τ_0	10 ns	10 ns	10 ns	10 ns
Initial Cal	f_0	11 ns	259 ns	1.8 s	7.3 s
Frequency Drift	f'_0	107 ps	62 ns	3 s	363 s
Instability	σ_y	10 ns	51 ns	135 ns	269 ns
	f[T				

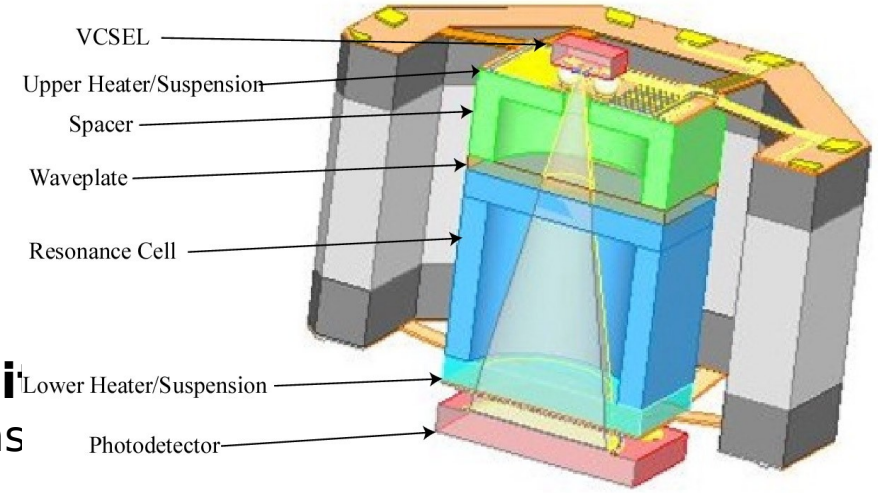
Limitations of gas cell atomic oscillators

TempCo and Drift have the same root causes:

- Pressure and composition of cell contents (“buffer gas shift”)
- Laser spectrum (“light shift”)

Superior performance requires:

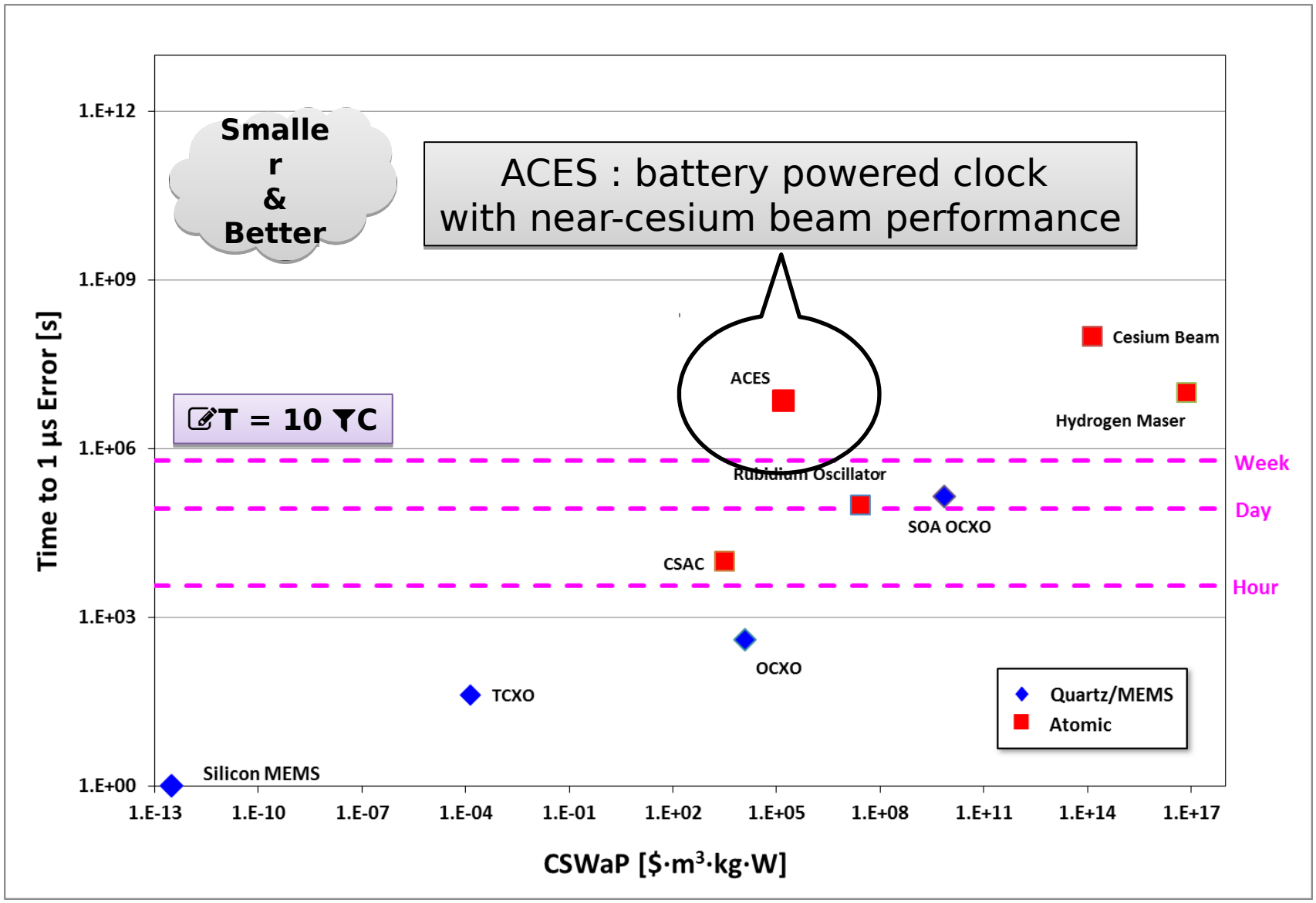
- Atoms in vacuum
- Light off during interrogation



Possible ACES interrogation archi

- Laser-cooled/trapped neutral atoms
- Trapped ions
- Interrogation of optical transitions
- Other?

ACES Program Goals



ACES Technical Areas

- **TA-1: ACES Clock Development**
  - Objective is to develop, test, and deliver hardware devices that meet or exceed the ACES program performance objectives.
  - Likely ITAR-restricted
  - Successful proposals will address all program performance objectives, including development, fabrication, integration, and test of all necessary component technologies.
  - Period-of-performance: three phases of 18/12/12 months
  - TA-1 proposals must not explicitly depend on any TA-2 efforts.

- **TA-2: Related Studies**
  - Objective is to explore and develop ACES-related technologies, including alternative physics approaches and methodologies, component technologies, and integration approaches.
  - Period-of-performance: three phases of 12/12/12 months
  - Possibly basic research

- **Both TAs**
  - Successful proposals will include measureable metrics, milestones, and deliverables within each phase and at the conclusion of each phase.

ACES TA-1 Program Milestones

TA-1 over three Phases:

	Proof-of-concept	Integrated Physics	Deliverable Clock
	Phase 1	**Phase 2**	**Phase 3**
Drift	N/A	$< 10^{-12}$/month	$< 10^{-13}$/month
TempCo (-40°C to +85°C)	N/A	$< 10^{-14}$/°C	$< 10^{-15}$/°C
ReTrace (on/off/on, 4/24/4 hours)	$\sigma_y < 10^{-11}$	$\sigma_y < 10^{-12}$	$\sigma_y < 10^{-13}$
Volume	N/A	30 cm^3	50 cm^3
Power	250 mW	250 mW	250 mW
Instability	$\sigma_y(\tau) < 1x10^{-11} / \tau^{1/2}$	$\sigma_y(\tau) < 1x10^{-11} / \tau^{1/2}$	$\sigma_y(\tau) < 1x10^{-11} / \tau^{1/2}$
Notes	Power applies to physics package, which includes all vacuum, optical, and thermal control components	Size and power apply to physics package only, which includes all vacuum, optical, and thermal control components	Size and power apply to fully packaged device, which includes all physics and electronic components

Government Furnished Equipment

- High Efficiency, Narrow Bandwidth Distributed Bragg Reflection Laser

Wavelength	**780**	**nm**
Output power	>15	mW
Operating Temperature	□85	▼C
Wall-plug efficiency	>30	%

- Optical isolators

Center wavelength	**780**	**nm**
Isolation	>30	dB
Transmission	>70	%
Volume	<0.5	cm^3

Abstract Information – Due March 1, 2016

Abstracts are not mandatory, but highly encouraged

Section II of the Abstract is limited to 12 pages

Section II – Abstract Details
A. Innovative claims
B. Metrics and Deliverables
C. Technical rationale, approach, and plan for achieving metrics
D. Related research
E. Proposed team and teaming arrangements

Proposal Information – Due May 1, 2016

Section II of the Proposal is limited to 30 pages

Section II – Detailed Proposal Information
A. Statement of Work (SOW)
B. Innovative Claims
C. Detailed Technical Approach
D. Risk analysis and mitigation plan
E. Schedule, milestones, and budget
F. Technology Transfer
G. Comparison with related research
H. Proposer's previous accomplishments
I. Management plan & key personnel
J. Test plan
K. Facilities and equipment

Evaluation Criteria

1) Overall scientific and technical merit
2) Potential contribution and relevance to the DARPA mission
3) Schedule realism
4) Cost realism
5) Proposers’ capabilities and/or related experience
6) Plans and capability to accomplish technology transition

www.darpa.mil